

sheet '3'

4-1

II

at L.P.F, sheet 2 is with 1000 Hz

$$\omega_c = 4 \text{ rad/sec}$$

so this circuit is denormalized L.P.F and it can't be transformed to any other filter type before we convert it to a normalized circuit

For L.P.F_n to L.P.F_d transformation

$$s = \frac{s}{\omega_c}$$

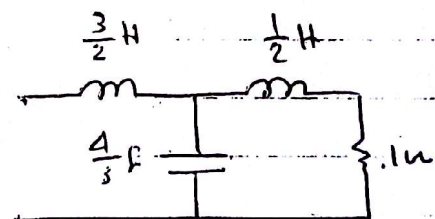
$$\ln s = \frac{L_n}{\omega_c} s = L_d s \Rightarrow L_d = \frac{L_n}{\omega_c} \Rightarrow L_n = L_d \omega_c$$

$$\frac{1}{C_n s} = \frac{1}{C_n \frac{s}{\omega_c}} = \frac{1}{\frac{C_n}{\omega_c} s} = \frac{1}{C_d s} \Rightarrow C_d = \frac{C_n}{\omega_c} \Rightarrow C_n = C_d \omega_c$$

$$L_{1n} = \frac{3}{8} \times 4 = \frac{3}{2} \text{ H}$$

$$L_{2n} = \frac{1}{8} \times 4 = \frac{1}{2} \text{ H}$$

$$C_n = \frac{1}{3} \times 4 = \frac{4}{3} \text{ F}$$



normalized L.P.F circuit

Convert it to H.P.F with $\omega_c = 10000 \text{ rad/sec}$

$$C_1 = 1 \mu\text{F} \quad ? \quad C_2 = 3 \mu\text{F}$$

Scaling Factor K

(2)

The coil is converted into capacitor

$$\text{---} \overline{\text{---}} \text{---} \xRightarrow{L_n} \text{---} \text{---} \text{---} C_d = \frac{1}{L_n \omega_c}$$

$$\text{---} \text{---} \text{---} C_n \xRightarrow{} \text{---} \overline{\text{---}} \text{---} L_d = \frac{1}{C_n \omega_c}$$

$$C_{d1} = \frac{1}{\frac{3}{2} \times 10000} = 0.666 \times 10^{-4} \text{ F}$$

$$C_{d2} = \frac{1}{\frac{1}{2} \times 10000} = 2 \times 10^{-4} \text{ F}$$

$$\text{before scaling} \leftarrow L_b = \frac{1}{\frac{4}{3} \times 10000} = 0.75 \times 10^{-4} \text{ H}$$

before impedance scaling

∴ after impedance scaling

taking $C_1 = 1 \mu\text{F} = 10^{-6} \text{ F}$

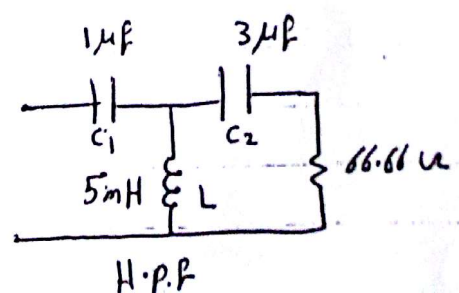
$$\therefore C_1 = \frac{C_{d1}}{K}$$

$$10^{-6} = \frac{0.666 \times 10^{-4}}{K}$$

$$\therefore K = \frac{0.666 \times 10^{-4}}{10^{-6}} = 66.66$$

$$\therefore L = L_b \times K = 0.75 \times 10^{-4} \times 66.66 = 50 \times 10^{-4} = \boxed{5 \text{ mH}}$$

$$R = 1 \times K = 1 \times 66.66 = \boxed{66.66 \Omega}$$



③

4-3] obtain the general transfer function

$$\frac{V_2}{V_1} = H(s) = \frac{Gb_0 s^2 / Q^2}{s^4 + \frac{b_1}{Q} s^3 + \left(2 + \frac{1}{Q^2}\right) s^2 + \frac{b_1}{Q} s + 1}$$

of 4th order B.P.F. with $\omega_c = 1$, 2 Gain G , quality factor Q .

For 4th order B.P.F. we require 2nd order L.P.F.

For 2nd order L.P.F. its transfer function is given by

$$H_{L.P.F.}(s) = \frac{Gb_0}{s^2 + b_1 s + b_0}$$

$$\therefore H_{B.P.F.}(s) = H_{L.P.F.}(s) \bigg|_{s = Q\left(\frac{s^2+1}{s}\right)}$$

$$H_B(s) = \frac{Gb_0}{\left(Q\left(\frac{s^2+1}{s}\right)\right)^2 + b_1 Q\left(\frac{s^2+1}{s}\right) + b_0}$$

$$= \frac{Gb_0}{Q^2 \frac{s^4 + 2s^2 + 1}{s^2} + b_1 Q s + b_1 Q \frac{1}{s} + b_0}$$

$$\times \frac{s^2/Q^2}{s^2/Q^2}$$

$$= \frac{Gb_0 s^2 / Q^2}{s^4 + 2s^2 + 1 + \frac{b_1}{Q} s^3 + \frac{b_1}{Q} s + \frac{b_0}{Q^2} s^2}$$

$$= \frac{Gb_0 s^2 / Q^2}{s^4 + \frac{b_1}{Q} s^3 + \left(2 + \frac{b_0}{Q^2}\right) s^2 + \frac{b_1}{Q} s + 1}$$



(4)

4-4 obtain $\frac{V_2}{V_1} = H_{B.R.} = \frac{G(s^2+1)^2}{s^4 + \frac{b_1}{b_0 Q} s^3 + \left(2 + \frac{1}{b_0 Q^2}\right) s^2 + \frac{b_1}{b_0 Q} s + 1}$

of 4th order Band reject filter

From the second order L.P.F

$$H_L(s) = \frac{G b_0}{s^2 + b_1 s + b_0}$$

$$H_{B.R.}(s) = H_L(s) \Big|_{s = \frac{s}{Q(s^2+1)}}$$

$$H_{B.R.}(s) = \frac{G b_0}{\frac{s^2}{Q^2 (s^2+1)^2} + \frac{b_1 s}{Q (s^2+1)} + b_0} = \frac{G}{\frac{s^2}{b_0 Q^2 (s^2+1)^2} + \frac{b_1 s}{b_0 Q (s^2+1)} + 1}$$

$(s^2+1)^2$ ضرب الكل ، انما

$$\begin{aligned} H_{B.R.}(s) &= \frac{G (s^2+1)^2}{\frac{1}{b_0 Q^2} s^2 + \frac{b_1}{b_0 Q} s (s^2+1) + (s^2+1)^2} \\ &= \frac{G (s^2+1)^2}{\frac{1}{b_0 Q^2} s^2 + \frac{b_1}{b_0 Q} s^3 + \frac{b_1}{b_0 Q} s + s^4 + 2s^2 + 1} \end{aligned}$$

$$= \frac{G (s^2+1)^2}{s^4 + \frac{b_1}{b_0 Q} s^3 + \left(2 + \frac{1}{b_0 Q^2}\right) s^2 + \frac{b_1}{b_0 Q} s + 1}$$

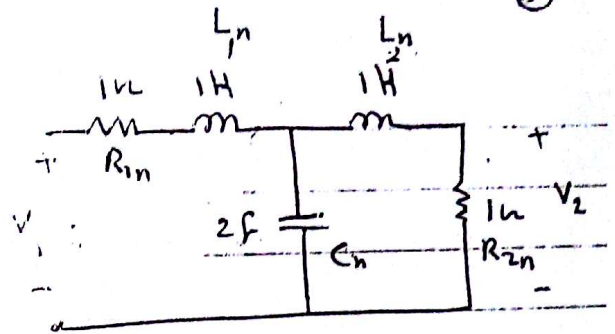
(5)

4-7 obtain B.P.F

$$\omega_0 = 10^5 \text{ rad/sec}$$

$$Q = 10$$

$$K = 10^3$$



the impedance of the resistor don't change with the frequency transformation

For L.P.F $\xrightarrow{\omega_0}$ B.P.F transformation

$$s = \frac{s^2 + \omega_0^2}{Bs}$$

$$Q = \frac{\omega_0}{B}$$

$$\therefore \beta = \frac{\omega_0}{Q} = \frac{10^5}{10} = 10^4 \text{ rad/sec}$$

$L_n \rightarrow$ is replaced by inductance $L_d = \frac{L_n}{B}$ in series

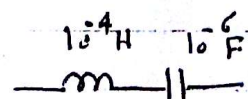
with capacitance $C_d = \frac{B}{\omega_0^2 L_n}$

$C_n \rightarrow$ is replaced by inductance $L_d = \frac{B}{\omega_0^2 C_n}$ in parallel

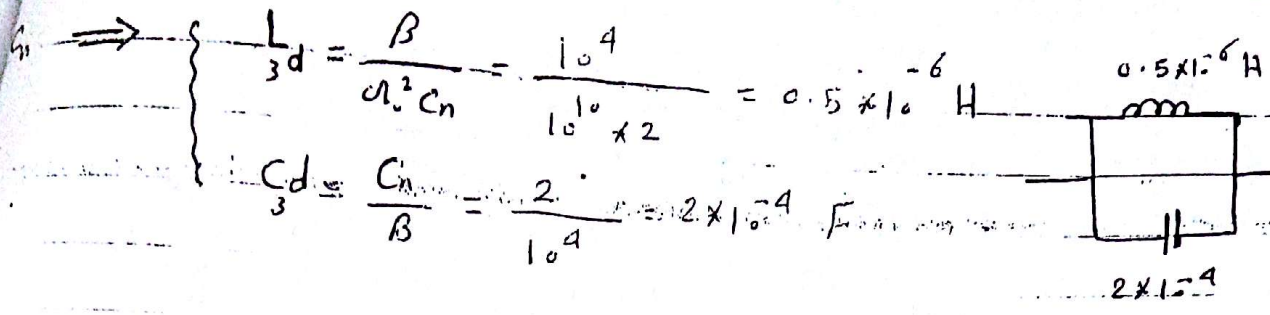
with capacitance $C_d = \frac{C_n}{B}$

$$L_{1n} = 1 \text{ H} \Rightarrow L_{1d} = \frac{L_{1n}}{B} = \frac{1}{10^4} = 10^{-4} \text{ H}$$

$$C_{1d} = \frac{B}{\omega_0^2 L_{1n}} = \frac{10^4}{10^{10} \times 1} = 10^{-6} \text{ F}$$



⑥



$$L_1 = L_d \times K = 10^{-4} \times 1000 = 0.1 \text{ H}$$

$$C_1 = C_d / K = 10^{-6} / 1000 = 10^{-9} = 1 \text{ nF}$$

$$L_2 = 0.1 \text{ H}$$

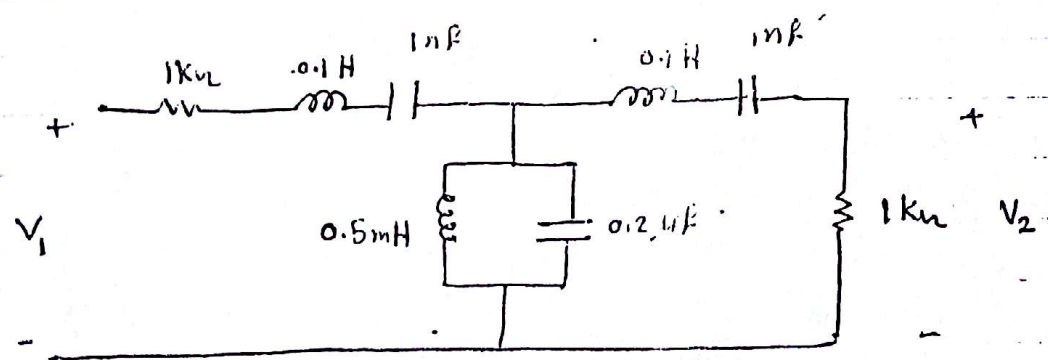
$$C_2 = 1 \text{ nF}$$

$$L_3 = L_d \times K = 0.5 \times 10^{-6} \times 1000 = 0.5 \text{ mH}$$

$$C_3 = C_d / K = \frac{2 \times 10^{-4}}{1000} = 2 \times 10^{-7} = 0.2 \text{ }\mu\text{F}$$

$$R_1 = R_{in} \times K = 1 \times 1000 = 1 \text{ k}\Omega$$

$$R_2 = R_{2n} \times K = 1 \times 1000 = 1 \text{ k}\Omega$$



6th order B.P.F